THE RESULTS OF SCIENTIFIC INVESTIGATIONS CONCERNING THE EFFECTS OF ALCOHOL ON THE LIVING HUMAN SYSTEM.

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DURING the last fifty years our knowledge of organic and analytic chemistry, together with the invention and application of instruments of precision for conducting chemical, physiological, and pathological investigations, has increased with great rapidity.

Pari passu with each step in this rapid progress in developing the methods and means for strictly scientific research has alcohol as it exists in the fermented and distilled liquors attracted attention and investigation. Such investigation early demonstrated it to be a simple carbo-hydrate, consisting of carbon, hydrogen, and oxygen, and in a pure undiluted state actively destructive to both vegetable and animal life. It was found not only to destroy the vitality of such animal tissues as it came in contact with, but to retard or prevent their decay after their death. Further investigation, aided by the microscope, proved it to be exclusively the product of the action of bacteria on saccharine matter in the process called fermentation. It displays but feeble affinity for the oxygen or nitrogen of the atmosphere at ordinary temperatures, but a very strong affinity for water and both vegetable and animal albumens. When largely diluted, as in the various fermented and distilled liquors in use, it may be introduced into the living human system through the stomach, and its effects investigated with all the accuracy afforded by modern chemical and philosophical methods. The presence of diluted alcohol in the human stomach directly diminishes the digestive power of the pepsin, as shown by many investigators and more recently by Hugouneng (*Lyon Medical*, March 1, 1892), and it holds in check the secretion of gastric juice until it is absorbed, when the secretion returns. This appears to have been clearly shown by Gluzinski ("Deutches Archiv. fur klinische Medicin," B. 29, p. 423, Leipzig), who experimented on the human stomach by administering moderate quantities of alcohol with food and withdrawing the contents of the stomach for examination at different periods of time. He found that the alcohol rapidly disappeared from the stomach by absorption, as there was neither aldehyde nor other products of alcoholic oxidation in the stomach contents, and very little digestion of albumen. But when the alcohol had been entirely removed a rapid increase in the acid secretion of gastric juice took place and active digestion followed; and in some instances the secretion continued after the digestion of food was completed. It is evident that the direct contact of the alcohol

with the gastric mucous membrane caused dilatation or congestion of the vessels and tubules, thereby checking the secretion so long as such contact remained, but as soon as it had been removed by absorption the congested vessels yielded a more rapid flow of secretion than natural. It is evident also that if the contact of the alcohol should be repeated daily, or several times a day for any considerable length of time, the gastric mucous membrane would become permanently congested and its secretion perverted, as seen in all cases of chronic alcoholism. The alcohol absorbed from the contents of the stomach is carried by the portal veins in part directly to the ascending vena cava and right cavities of the heart, and in part indirectly after distribution through the liver. From the right cavities of the heart it is carried with the current of blood through the lungs to the left cavities of the heart, and from thence to every part and tissue of the living body unchanged in form or composition.

Since Dr. Percy, many years since, so clearly demonstrated the presence of free alcohol in the brains of drinkers other investigators have found it present in the liver, spleen, kidneys, lungs, and muscles. Dr. J. E. Usher, in his recent work on Alcoholism and its Treatment, says: "In several cases, after death, I have been present when pure alcohol was obtained by simple distillation." That it does thus circulate with the blood through all the tissues of the body is further proved by the fact that it is readily detected in the eliminations from the lungs, skin, kidneys, and the glandular secretions generally. Conceding the well-established fact that diluted alcohol undergoes no digestive change in the stomach, but is rapidly absorbed and carried with the blood into all the tissues of the body, three questions of paramount importance are presented for solution: 1st. What are the effects of its presence on the blood itself? 2d. What are the direct effects of its presence on the various structures to which it is carried? 3d. What are the secondary or remote effects of its protracted presence as in cases of habitual or frequent repetitional use?

In answering the first of these questions the fact, conceded by all chemists, that alcohol displays a strong affinity for the water, albumen, and hemoglobin of the blood must be kept in mind. Hence its presence in contact with these constituents of the blood could hardly fail to alter either their forms or functions or both.

Using the microscope Dr. B. W. Richardson, of London, early claimed that the presence of alcohol altered the natural contour of the red corpuscles and promoted their disintegration. Virchow in studying the condition of the blood drawn from an inebriate, says he found "a decrease of water and an increase of fibrine and of colored clots." Dr. J. E. Usher, in his work, previously quoted, while prosecuting a series of experiments on the blood of persons affected with chronic alcoholism, says: "Repeatedly the red corpuscles were found to be irregular in outline, presenting a contracted or shrunken surface. Apparently a partial coagulation had taken place, with a decided diminution in size. . . . . The chief pathological changes noted are to be found in a contraction of the cells, with some evident exudation of the coloring matter, and an entire loss of their normal outline. The leucocytes offer a striking contrast, being more numerous;

but, instead of disorganization, these cells indicate that a coagulation of the nuclei has taken place, and they seem to be enlarged or swollen in a surprising degree." He states further that the blood examined was less alkaline than normal, and that crystals were augmented in quantity. Magnus Huss and others have noticed in the blood of habitual drinkers an excess of fatty globules, and Usher says: "Anemia is not an uncommon concomitant of alcoholism, the blood becoming very poor and watery—the white corpuscles being much in excess of their normal quantity. The liquor sanguinis is poor in albuminoids, and the salts are usually in excess. So poor in hemogoblin may the blood become that it is not a singular thing to find the red corpscules reduced to 60 parts in 1,000 parts of blood," which is less than half their natural proportion. In addition to the foregoing changes in the constituents of the blood, the direct experiments of Prout, Bocker, myself, Hammond, and quite recently Bodlander, have proved that the presence of alcohol diminishes both the absorption or reception of oxygen, and the exhalation of carbon-dioxide through the air cells of the lungs.

As the reception of oxygen by the hemoglobin and serum of the blood from the air cells of the lungs, and the elimination through the same channel of the carbon-dioxide, constitute the chief function of the lungs, the influence of alcohol in diminishing that function uniformly and in a notable degree, is one of its most important effects relating to its use either as a drink or a medicine.

Perhaps no fact in human physiology is better established than that oxygen is being constantly received from the pulmonary air cells by the hemoglobin and serum of the blood, by which it is conveyed in the arterial blood to every tissue of the body, and by its presence sustains nerve sensibility, secretory action, and all the metabolic or molecular movements that constitute assimilation, nutrition, disintegration, and excretion. Consequently whatever diminishes the capacity of the hemoglobin and serum for taking up the oxygen from the pulmonary air cells, diminishes all the metabolic processes in the living body. That the presence of alcohol in the blood does thus diminish the capacity of the hemoglobin and serum for taking up the oxygen, is not only proved by the diminished amount of oxygen taken up and of carbon-dioxide exhaled, as shown by the investigators just named, but also by the early and well-executed experiments of Bocker, of Germany, and W. A. Hammond, of this country, showing that it diminished the aggregate of all the secretions and eliminations, and more recently by Mohilinsky, who experimented on fifteen healthy young men, a part of whom were habitual moderate drinkers and part were total abstainers. The amount of alcohol given to each varied from two to five ounces per day. In all those who had been total abstainers he found the assimilation of the nitrogenous elements of food and of fat or oil diminished; and, in nearly all, the retrograde metabolism or nitrogenous disintegration was diminished an average of nearly nine per cent. These effects are attributed by V. A. Manassein, Schmiedeberg, and Bocker to the influence of alcohol in inhibiting the systemic oxidation processes, dilating the blood-vessels, lessening arterial tension, retarding circulation, and lowering tem-

perature. The experiments of Schulinus and Salzynski pretty clearly demonstrate that about ten per cent. of the alcohol taken into the blood immediately disappears, or, at least, loses its identity. As such disappearance is not accompanied by either increase of heat or of carbon-dioxide, or of consumption of oxygen, it cannot be from the sudden oxidation of that amount of alcohol, as is generally supposed. Moreover, alcohol at the ordinary temperature of the atmosphere, or of the human body, displays but a feeble affinity for oxygen, while its affinity for the elements of the serum and hemoglobin of the blood is very active. And that this active affinity of the alcohol causes some important molecular changes in the serum and corpuscular elements of the blood, is not only shown by the decrease of water and the increase of fibrine, as stated by Virchow, but also by its retarding, and when present in larger quantity preventing the conversion of hemoglobin into oxyhemoglobin, as fully demonstrated by Dr. George Harley, of London, Dr. J. D. Kales, of Chicago, and others. Dr. Harley showed that the addition of five per cent. of alcohol to fresh arterial blood completely destroyed the capacity of the hemoglobin for further oxygenation or for purposes of nutrition. Dr. Kales found that when absolute alcohol in varying quantities, from one to five per cent., was mixed with the freshly drawn blood, diluted with distilled water, it made no perceptible change in the oxyhemoglobin spectral bands at ordinary atmospheric pressure and a temperature of 98° F. Neither was there any evidence of oxidation of the alcohol. But when the pressure was diminished by means of the air-pump the oxyhemoglobin was rapidly reduced by surrendering its oxygen, which did not combine with the elements of the alcohol present, but escaped in a free state. It was further shown that when the oxyhemoglobin was reduced in contact with the alcohol it was less capable of re-oxygenation than when reduced without the presence of alcohol.

The second question, What are the direct effects of the presence of alcohol on the various structures to which it is conveyed in the blood, has already been answered in part by the facts quoted from Bocker, Hammond, Mohilinsky, Manassein, and others, to the effect that it diminishes in a marked degree retrograde tissue metabolism or oxidation processes and their products, such as carbon-dioxide, urea, phosphates, heat, etc. In fact, the results of all scientific investigations concerning the effects of alcohol on the metabolic processes in living tissues, have shown that its presence retards those processes more particularly as regards the nitrogenous metabolism dependent upon the presence of oxygen. The influence of alcohol in lessening the internal distribution of oxygen and in retarding tissue metabolism, necessarily involves impairment or disturbance of the functions of every important organ. Its influence on the stomach and lungs has already been stated. But in addition to those statements regarding the effects of alcohol on the functions of the stomach it is proper to refer to an unusually careful and extended series of experiments by Blumenau on five young men between the ages of 22 and 24 years. He gave the alcohol, diluted, from ten to twenty minutes before the dinner, consisting of soup, cutlet, and bread. The results are given in the Annual of Universal Medical Sciences, 1891, Vol. 9, letter 1 p. 4, as follows: "1. During the first

three hours after the ingestion, the gastric digestion is markedly retarded, which is dependent upon diminished digestive power of the gastric juice; in other words, upon a decrease in the proportion of hydrochloric acid present therein. 2. The diminution is especially pronounced in persons non-habituated to the use of alcohol. 3. Stronger solutions of alcohol act more energetically than weaker ones. 4. During the fourth, fifth, and sixth hours after the meal, the digestion becomes considerably more active, the proportion of hydrochloric acid markedly rising. 5. Under the influence of alcohol, the secretion of gastric juice becomes more profuse and lasts longer than under normal conditions. 6. The motor and absorptive processes of the stomach, however, are markedly depressed, the decrease being directly proportionate to the strength of alcoholic solutions ingested. 7. Alcohol distinctly retards the passage of food from the stomach into the duodenum. 8. On the whole, alcohol manifests a decidedly unfavorable influence on the course of normal gastric digestion. Even when ingested in relatively small quantities, the substance tends to impair all gastric functions. 9. Hence an habitual use of alcohol by healthy people cannot possibly be approved of from a physiological standpoint."

Glazer (see Deut. Medicin. Wochensch, Leipzig, Oct. 22d, 1891) has given the results of an extensive series of experiments to determine the effects of alcohol on the urine and the kidneys. His conclusions are given in the Annual of Universal Medical Sciences as follows: "That alcohol, even in relatively moderate quantities, irritates the kidneys, so that the exudation of leucocytes and the formation of cylindrical casts may occur. It also produces an unusual amount of uric-acid crystals and oxalates, due to the modified tissue changes produced by the alcohol. The effect of a single act of over-indulgence in alcohol does not last over thirty-six hours, but it is cumulative under continued use." Chittenden, in experimenting on dogs by keeping them under the influence of alcohol eight or ten days, found the elimination of uric acid in the urine to be increased 100 per cent. over the natural proportion. The effect of alcohol on the total amount of urine secreted is stated differently by different observers, some claiming that it is increased and others the reverse. I think these contradictory results depend upon the coincident conditions in each case. It is well known that drinking freely of water directly increases the flow of urine; consequently if alcohol is taken largely diluted with water, as in beer, the influence of the latter may be sufficient to maintain an increase in the quantity of urine. But if the alcohol is taken without such dilution the renal secretion is both diminished and altered in quality as stated by Glazer.

The direct effects of alcohol on the functions of the liver in regard to the quantity and quality of the bile secreted, have not been determined with as much accuracy by investigators as in reference to the functions of the stomach, lungs, and kidneys. But that it interferes with such secretion more or less, and still more impairs the glycogenic and ptomaine destroying action of the liver, is shown by the frequent and extensive changes found in the organ in chronic alcoholism, and the readiness with which habitual drinkers succumb to almost all acute infectious diseases. Of all the organs or important structures of the body, none are more directly and

uniformly influenced by alcohol than the nervous. Carried in the arterial blood into contact with all the delicate nerve cells and fibres of the body, its immediate effect is that of an anæsthetic, diminishing the sensibility and impairing the natural functions, both sensory and motor. That it produces these effects when given in liberal doses all concede; and if the dose is large enough or frequently repeated, it suspends all sensibility and action, and life is ended. But it has been, and still is, very generally claimed that in small or moderate doses it is stimulating and tonic, increasing nerve sensibility and muscular force, and anæsthetic or paralyzing only in larger quantities. The same paradoxical or contradictory effects have been ascribed by medical writers to all the anæsthetics and narcotics as ether, chloroform, opium, etc., but just when or in what quantity any one of them ceases to be a stimulant and begins to paralyze, no writer or experimenter has been able to decide. And an accurate analysis of the symptoms or effects produced by alcohol in every variety of dose from 4 grammes (3 i) or teaspoonful to a half pint, will show that no such opposite effects are produced at any stage of its influence. All who are conversant with the physiology or functions of the brain and nerves know that all sensations and muscular movements are regulated by nerve influence. The action of the heart and the movement of the blood in the vessels are directly under the control of the cardiac and vaso-motor nerves, and some of the fibres of these nerves are excitors of action and others are inhibitors, and it is the regulating influence of the latter that keeps uniformity and harmony in the circulation of the blood. All our voluntary movements and sensations manifested by the cerebro-spinal nerves have also their excitors and inhibitors by which we are enabled to co-ordinate muscular contractions and relaxations in executing all our voluntary movements, however complex. Equally true it is, that our mental actions as manifested through the convolutions of the brain, are regulated by excitors or sensations, and inhibitors. Every individual whose brain is in its natural condition has frequent sensations, impulses, or excitors of mental action which he promptly inhibits or disregards. It is on the proper development of this mental inhibition that every person's self-control and sense of propriety depend. If these physiological facts are kept clearly in mind we shall be able to interpret more correctly the influence of both small doses and large doses of alcohol on the human system. Thus a moderate dose circulating in the blood, by directly diminishing the sensibility of the cardiac and vaso-motor nerves immediately lessens the tension of the blood-vessels allowing them to dilate, and by simultaneously lessening the sensibility of the cardiac inhibitors, allows the heart to beat faster, but the efficiency of the circulation is diminished in proportion to the vascular dilatation and the cardiac frequency. At the same moment the presence of the alcohol is diminishing the sensibility of the cerebro-spinal nerves of ordinary sensation and consequently the individual is less conscious of cold, heat, pain, weariness, weakness, or even of his own body-weight, not because the alcohol either warms or cools or strengthens, as is popularly supposed, but simply because it diminishes the sensibility of the nervous channels through which all sensations or impressions are conveyed to the seat of consciousness in the brain.

At the same time the alcohol in the same moderate dose is so far diminishing the sensibility of the mental part of the brain itself as to impair both the acuteness of mental impressions and the mental inhibition; thereby imparting a feeling of ease, lightness, and lessened self-control, that makes the person feel as though he could move with less resistance and accomplish more in a given time than before he took the alcohol. It is exactly this diminished cerebral and nerve sensibility produced by a very moderate dose of alcohol, which inclines the individual to talk without reserve, sing songs, dance, or fight, in accordance with his surroundings, that make both him and his friends think the alcohol a stimulant. Yet give him another dose of the alcohol and diminish the sensibility of his nerve cells and fibres a little more, and he still thinks he could do more and do it faster, while the greater loss of self-control and muscular co-ordination renders him incapable of either walking or talking with steadiness. Give him another dose and he soon sinks into a state of complete anæsthesia with neither muscular power nor mental consciousness. The process from the beginning to the end is one of progressively diminished nerve sensibility and action, with no stage of increased force either physical or mental. The truth of this has been abundantly demonstrated on every field of human labor, civil and military, physical and mental. And it is further demonstrated by the results of the most accurately devised experiments conducted by Prout, Bocker, Hammond, Richardson, Ridge, Anstie, Harley, Sidney-Ringer, Dubois, Fife, Lauder-Brunton, Martin, Parkes and Wallowics, H. C. Wood, Reichert, Vierodt, Hervier and St. Layer, Smith, Perrin, and Lehmann. After carefully reviewing the work of all these in the Dublin *Journal of Medical Science*, September, 1891, Dr. E. MacDowel Cosgrave concludes that "contrary to what has been and is supposed, it is found, from all these researches, that small doses of alcohol produce, from the first, a narcotic rather than a stimulating effect."

But I must hasten to the answer of the third question, namely, What are the secondary or remote effects of the protracted presence of alcohol in the system, as in the case of habitual drinkers? From what has been already said regarding the direct action of alcohol on the constituents of the blood, the internal distribution of oxygen, and on the metabolic or molecular changes in the tissues, we should expect its protracted use would produce structural changes of importance in every living structure of the body. And unfortunately the frequent opportunities for examining the bodies of those dying from chronic alcoholism have abundantly verified that expectation. The blood itself is found impoverished of its hemoglobin, corpuscular and nutritive elements, with an excess of excretory products. The secreting organs, including the stomach, liver, spleen, pancreas, and kidneys, undergo fibroid, and sometimes fatty degeneration, with atrophy of their secretory cells. The lungs undergo the same fibroid sclerosis constituting chronic interstitial pneumonia or fibroid phthisis, though less frequently than the liver and kidneys. The changes in the muscular structures are more in the direction of fatty degeneration than fibroid. And, as remarked long since by Lancereaux and Trousseau, "The appearance of the heart in alcoholism is quite special; the fat does not merely line (or cover) the heart, but

likewise penetrates between the muscular fibres, and induces atrophy by the compression it exerts upon them; at a later date the muscular fibres become fatty." The changes induced by alcoholism in the nervous structures, both central and peripheral, are also well-marked and important. These changes are briefly described by one writer, as follows: "The characteristic changes which have been observed in the brain, medulla oblongata, etc., of confirmed drinkers, consist essentially of a peculiar atrophic modification by which the true elements of nerve tissue are partially removed; the total mass of nervous matter wastes, serous fluid is effused into the ventricles and the arachnoid, while simultaneously there is a marked development of fibrous tissue, granular fat, and other elements which belong to a low order of vitalized products." The same changes have been more recently found extensively in the peripheral nerves in cases of alcoholic neuritis. It is these steadily progressive degenerative changes in the brain and nerves that cause the habitual drinker so frequently to suffer from vasomotor paralysis and so-called heart failure; from neuritis, neurasthenia, anæsthesia, paralysis, serous apoplexy, and various forms of mental derangement. Even the procreative organs of both sexes are found to suffer similar degenerative changes and impairments, as has been demonstrated experimentally by Mairet and Combernal, in Paris.

In view of all the foregoing investigations and established facts I ask whether there is any rational basis for the claim that alcohol is either a stimulant, tonic, or conservator of tissue? Can an agent that directly diminishes nerve sensibility and muscular contraction, in direct ratio to the quantity given, ever act as a true stimulant or tonic? Can an agent that by its affinity for the hemoglobin and serum of the blood diminishes the internal distribution of oxygen and markedly retards the metabolic or both nutritive and disintegrative changes, possibly conserve or protect any natural tissue? Instead of conserving, is not its effect necessarily degenerative, as we see everywhere following the persistent use of alcohol? These are questions of momentous importance to the human race. The duty and responsibility of giving them correct answers belong to the members of the medical profession. In view of all the strictly scientific investigations thus far, I do not hesitate to answer that alcohol when taken into the human system acts directly as an anæsthetic and retarder of all natural metabolism, nutritive, disintegrative, and secretory; and when persistently used causes tissue degenerations that impair health and shorten life.